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Directorate of Intelligence

Project Babylon: The Iraqi Supergun (U)

A Research Paper

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November 1991

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Directorate of
Intelligence

Project Babylon: The Iraqi Supergun (U)

A Research Paper

This paper was prepared by [redacted] Office of Scientific and Weapons Research, with contributions by [redacted] OSWR. Comments and queries are welcome and may be directed [redacted]

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Project Babylon:
The Iraqi Supergun (U)

Summary

Information available as of 9 October 1991 was used in this report.

From 1988 until 1990, Iraq was involved in an unusual weapons development program it called Project Babylon. This project included the development, manufacture, and construction of several large-caliber guns, including a 1,000-millimeter-diameter supergun. In addition, Project Babylon encompassed the development of projectiles for these guns that included conventional and rocket projectiles capable of being fired to great distances—on the order of a 1,000 kilometers for the gun-launched rockets. This project was coordinated for Iraq by the Space Research Corporation (SRC), which was also heavily involved in the development of the guns and projectiles. [redacted] these guns were intended for the bombardment of unspecified military and economic targets. ~~(S NF NC)~~ (b)(1) (b)(3)

By early 1990, Iraq had successfully built and fired a 350-mm-diameter scaled version of the 1,000-mm supergun. Also, by this time, many components for the 1,000-mm supergun and two other 350-mm guns—whose immense size required out-of-country manufacture—had been delivered to Iraq. However, construction of the supergun and the two other 350-mm guns had not begun. ~~(S NF)~~

In March 1990, the murder of Gerald Bull, the project leader, was the first link in a chain of events that drastically slowed the progress of Project Babylon and ultimately led to its termination. Worldwide disclosure in April 1990 of the project occurred when UK Customs seized the last eight sections that were to make up the 1,000-mm gun barrel. Other components, including several critical components like gun-barrel sections and breeches, were subsequently seized by various countries. Without these critical components, the supergun could not have been completed by Iraq. We are unable to find any evidence that Iraq obtained out-of-country aid for the project after its disclosure. ~~(S NF)~~

In July 1991, in the aftermath of the Persian Gulf war, Iraq acknowledged "a long-range gun program," despite its initial denials that there was such a program. The Iraqis also admitted to the existence of the 350-mm diameter test gun and to its location, and they provided information on status of the components that were to make up the 1,000-mm supergun and two other 350-mm guns. Examination of the 350-mm test-gun site, the supergun components, and other gun components by a United Nations inspection team revealed that Project Babylon has, in fact, been terminated. In October 1991, procedures were implemented by the United Nations for the destruction of the Project Babylon components, including the 350-mm test gun. (U)

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SW 91-10076X
November 1991

Contents

~~Secret~~
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ORCON

Gerald Bull

At age 22, Gerald Bull was one of Canada's youngest citizens to earn a doctorate in aerodynamics (see figure 1). He became known for creative solutions—using a gun instead of a wind tunnel to conduct inexpensive hypervelocity aerodynamic studies—and for his impatience with what he termed "amateur scientists" and "bureaucratic redtape." At age 32, he led the extremely ambitious joint US-Canadian High-Altitude Research Project (HARP), developing state of the art for gun-launched projectiles and rockets. (U)

Soon after the end of the HARP program in 1967, Bull founded the Space Research Corporation (SRC) and built a test facility near Highwater, Quebec. He purchased the HARP guns and equipment at scrap-value prices from the US and Canadian Governments—apparently considering the idea of reviving his dream of building large-caliber guns. Through a special act of the US Congress in 1972, Bull was granted US citizenship and a security clearance and was awarded up to $9 million in defense contracts. After the establishment of an SRC subsidiary in Belgium, Bull developed the GC-45 gun—considered to be one of the best artillery guns in the world—and advanced projectiles with almost twice the range of guns in the US arsenal. (U)

Bull was unsuccessful in convincing the US Army to purchase his GC-45 gun and ammunition. Therefore, he decided to sell the GC-45 to the South Africans with what he considered to be approval from the US Office of Munitions Control. Later, he was charged with violating the arms embargo to South Africa and, after pleading guilty in 1980, was sentenced to 6 months in prison. Upon release from prison, he vowed never to return to North America and moved his operations to Brussels. (U)

Bull continued to sell his GC-45 gun, ammunition, and technology worldwide; he sold at least 200 systems to Iraq in the mid-1980s. It is reported that Saddam Husayn was extremely impressed with these artillery guns. Further, it is possible that Bull personally persuaded Saddam Husayn to fund his dream: the building of a 1,000-millimeter supergun that could launch payloads into space as well as deliver warheads to great distances. In 1988, Iraq made Bull's SRC the managing authority for the supergun project, known as Project Babylon. ~~(S NF)~~

Project Babylon:
The Iraqi Supergun (U)

Background: Why a Supergun?

Project Babylon was Iraq's program to develop a supergun. The brainchild of Gerald Bull, a naturalized US citizen, the program was started by his Space Research Corporation (SRC) in 1988. Bull had been obsessed for almost 30 years with building the world's largest gun that would be capable of launching payloads into space. We believe that Bull, because of his obsession as much as any technical or military consideration, was instrumental in convincing Iraq to initiate Project Babylon (see inset and figure 1). ~~(S NF)~~

Figure 1. Gerald Bull, designer of the supergun, inspected one of his large-caliber guns in 1965. (U)

Few hard facts have been obtained about Iraq's requirements for Project Babylon. Speculation abounds on why Iraq funded a project to develop a 1,000-millimeter supergun, several 350-mm diameter guns, and their projectiles. Arguments within the Intelligence Community have ranged from the belief that the gun systems possess no benefits over comparable missile systems to the belief that the gun systems are better because gun-launched rocket projectiles would be difficult to intercept as compared with missiles. [redacted] (b)(1) (b)(3)
Bull considered a large-caliber gun firing rocket projectiles to be an efficient and reusable "first stage" capable of delivering moderately sized payloads (on the order of 100 kilograms [kg]). In addition, Bull boasted that a 1,000-mm gun system could be developed for far less cost than a comparable (in terms of payload) missile system. Our analysis generally supports Bull's conclusions. ~~(S NF NC)~~

The HARP Program: Forerunner to the Supergun

Project Babylon can be traced back to the 1960s joint US-Canadian High-Altitude Research Project (HARP), which used large-caliber guns to conduct upper-atmospheric research experiments. The HARP program succeeded in setting the world altitude record of 180 kilometers (km) for a gun-fired projectile. Further, the HARP program extended gun-launch technology, demonstrating that firing rockets from guns was feasible and that guns were theoretically capable of launching payloads to low Earth orbit or to targets thousands of kilometers downrange. The HARP program was ended in 1967 as missile technologies matured. (U)

The HARP program consisted of several guns, the largest being a modified US Navy 16-inch (406-mm) gun (see figure 2). This gun fired both subcaliber projectiles [1] and single-stage, solid rockets. One version of this gun—known as the Highwater gun because of its location in Highwater, Quebec—consisted of three 16-inch gun barrels bolted together. This gun was limited to horizontal firings over a flight range of 3 to 5 km (see figure 3). Test firings included projectile-sabot structural-proof tests and development testing of large, full-bore rockets with a total mass of about 1,000 kg. (U)

The state of the art for launching rockets from guns was reached during the HARP program. Specifically, difficulties associated with rocket-component and rocket-motor survival at high-launch accelerations, experienced while the rocket travels down the gun barrel, were solved. These solutions included the development of hardened components and a novel approach for supporting center-burning rocket motors. The program succeeded in firing a 180-mm fiberglass-wrapped rocket from a horizontally mounted gun (see figure 4). These tests proved that rockets could be fired from guns and, according to analysis by HARP scientists, to altitudes of over 500 km, depending on payload and rocket exit velocity. By the end of the HARP program, this development culminated in the construction of a 16-inch, two-stage solid rocket, known as Martlet 2G-1, which was fired from the gun in Highwater, Quebec, again in a horizontal position (see figure 5). HARP scientists began to design a different version of this rocket, one with three stages, which they believed would be capable of placing a small (size unspecified) payload into Earth orbit. (U)

The ultimate rocket projectile envisioned during the HARP program was a multistaged, full-bore rocket designated Martlet 4 (see figure 6). This rocket was designed to carry payloads of up to 200 kg to low Earth orbit. Work on this rocket projectile never progressed beyond the drawing board during HARP's duration. (U)

Figure 2. The 16-inch HARP gun firing at the Barbados Test Range. (U)

Project Babylon: Attempt To Build a Supergun

[redacted] Project Babylon loosely consisted of two phases and several subprograms. Some of these data refer to Phase I as (b)(1) (b)(3)

[1] A subcaliber projectile has a diameter smaller than the diameter of the gun barrel. A sabot is used to position the smaller diameter projectile within the gun barrel. Subcaliber projectiles are used primarily because of their lower mass as compared with full-diameter projectiles. Consequently, subcaliber projectiles can be fired at higher velocities than would be capable with full-diameter, heavier projectiles. A disadvantage of subcaliber projectiles is that they have a smaller (sometimes much smaller) payload capacity. (U)

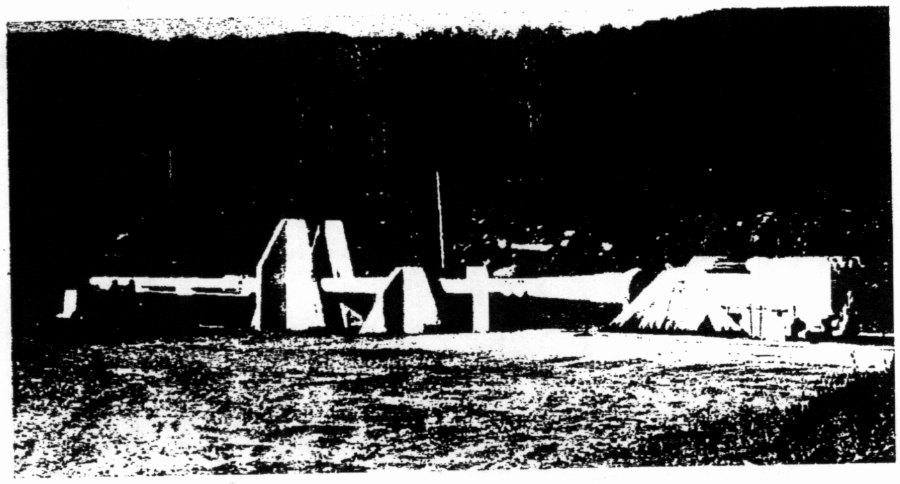
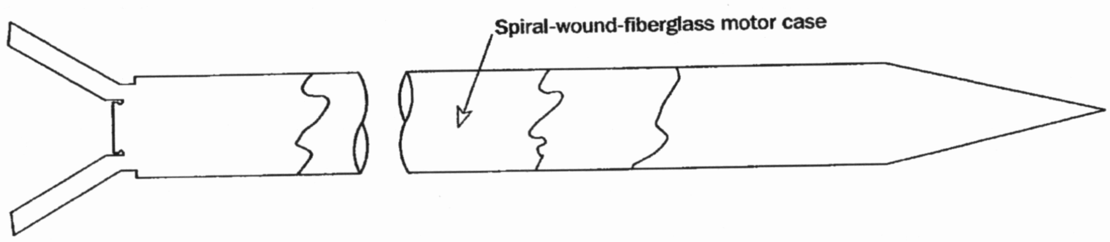


Figure 3. This 16-inch gun in Highwater, Quebec, was made by joining three 16-inch naval gun barrels together. It was used to develop gun-launched rocket projectiles. (U)

Figure 4
Martlet 3E Gun-Launched Rocket



The Martlet 3E gun-launched rocket was fired from one of the HARP guns.

332911 11-91

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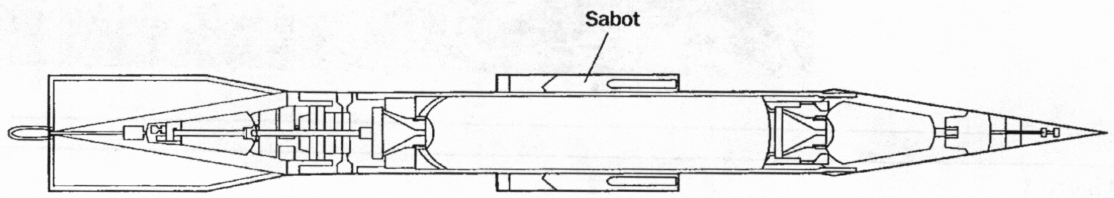
Figure 5
Martlet 2G-1 Gun-Launched Rocket



The Martlet 2G-1 was fired from the 16-inch gun in Highwater, Quebec.

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Unclassified 332912 11-91

the design and construction of two large, 1,000-mm superguns and to Phase II as the design and construction of two smaller elevating and traversing 350-mm guns (see figure 7). [redacted] Phase II was the development of gun-launched rockets (GLRs) for both the 1,000-mm and 350-mm guns. We differentiate between the various phases and subprograms as follows. (~~S NF NC~~ OC)

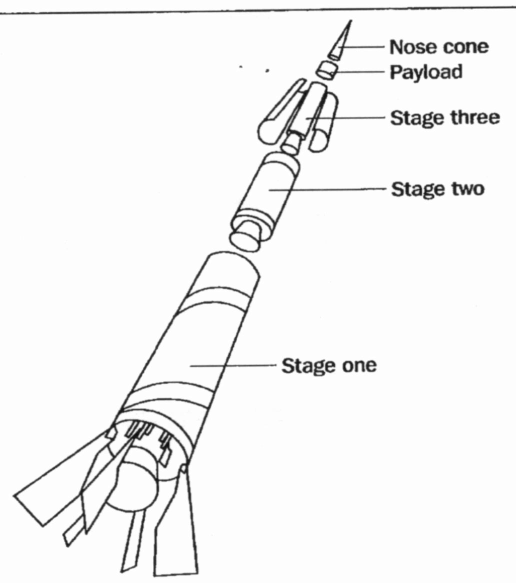
Phase I

Phase I involved a 1,000-mm-diameter supergun designated S-1000 (see figure 8). This gun was to have a barrel length of 150 meters and was to have been emplaced in a fixed position on a mountainside at about a 45-degree elevation. This gun would be able to fire on targets only along its fixed gun-target line.

(b)(1)
(b)(3)

[redacted]

Figure 6
Martlet 4 Gun-Launched Rocket



The Martlet 4 was to be a multistage, full-bore, gun-launched rocket. The intent of this rocket, fired from the 16-inch HARP gun, was to launch payloads into low Earth orbit.

[redacted]

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332913 11-91

According to our analysis [redacted] no construction of the 1,000-mm supergun had ever occurred. (S ~~NF NC~~ OC)

Supporting Phase I was a scaled version of the S-1000 supergun, known as the S-350 L150, with a 350-mm-diameter barrel (see the section, "The Only Gun To Fire: The S-350 L150"). This smaller scale gun was successfully test-fired, in a horizontal position, using test slugs and subcaliber projectiles. It was later moved to an inclined site for further testing to more accurately replicate the emplacement of the larger supergun. (S ~~NF~~ NC OC)

Also supporting Phase I was another 1,000-mm-diameter test gun that was to have been mounted horizontally for test firings. This gun was to be the prototype whose data would have been combined with that of the 350-mm test gun for incorporation into the finalized design of the operational 1,000-mm supergun. [redacted] we know that some preliminary work on the support structure for the 1,000-mm horizontal gun had been done by early 1990. Even though the fabrication of some 1,000-mm horizontal-gun parts had occurred, construction of the gun itself had never been started. (S ~~NF~~) (b)(1) (b)(3)

Phase II

We believe that Phase II of Project Babylon involved two 350-mm-diameter guns, designated S-350 ET, capable of elevating and traversing (see figure 9). These guns would provide a more flexible system than the fixed supergun for targeting—the capability to fire on targets at various azimuths. SRC gun designers indicated, as revealed in documentary data, that the payload capacity of the subcaliber projectiles would be very small—about 15 to 20 kg. The designers began planning GLRs that would provide these 350-mm guns with the capability to deliver a 100-kg payload to a range of about 1,000 km. We believe, therefore, that GLRs were intended as the primary projectile for these smaller guns. (S ~~NF~~)

Other Guns

Separate from Phase I or II were guns of 500-mm and 600-mm caliber proposed by the SRC and at least considered by Iraq. Initially, a 500-mm gun was examined to address the issue of the small-payload capacity of the S-350 guns, particularly with their subcaliber projectiles. This 500-mm gun, like the S-1000, would be in a fixed position and fire both GLRs and subcaliber projectiles. No construction or component procurement for this gun occurred. (S ~~NF NC~~) (b)(1) (b)(3)

Figure 7
Guns of Project Babylon

Phase I: **Goal:**
- 1,000-mm operational supergun

Status:
- Some components delivered
- No construction of 1,000-mm operational supergun
- Some components seized
- 350-mm gun constructed and test-fired

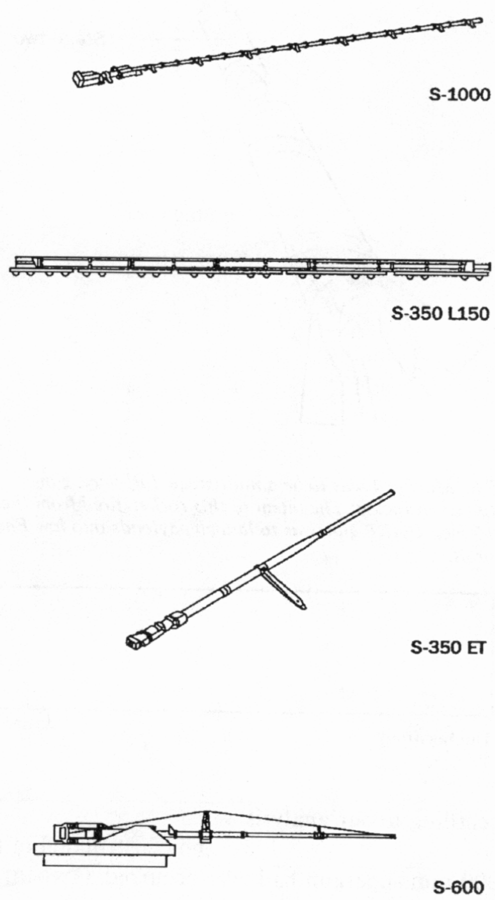
Support:
- Scaled 350-mm test gun initially in horizontal position
- Later disassembled and reassembled on side of mountain
- Full-scale 1,000-mm test gun was to be horizontally mounted for test firings

Phase II: **Goal:**
- Two 350-mm operational guns capable of elevating and traversing

Status:
- Components procured
- No construction
- Some components seized

Other guns:
- 600-mm gun
- 500-mm gun

Status:
- Only on drawing board
- No construction
- No components procured



These guns comprised Project Babylon, whose goal was to build a 1,000-mm supergun and two 350-mm elevating and traversing guns. Of the guns considered, only a 350-mm test gun was ever built and fired.

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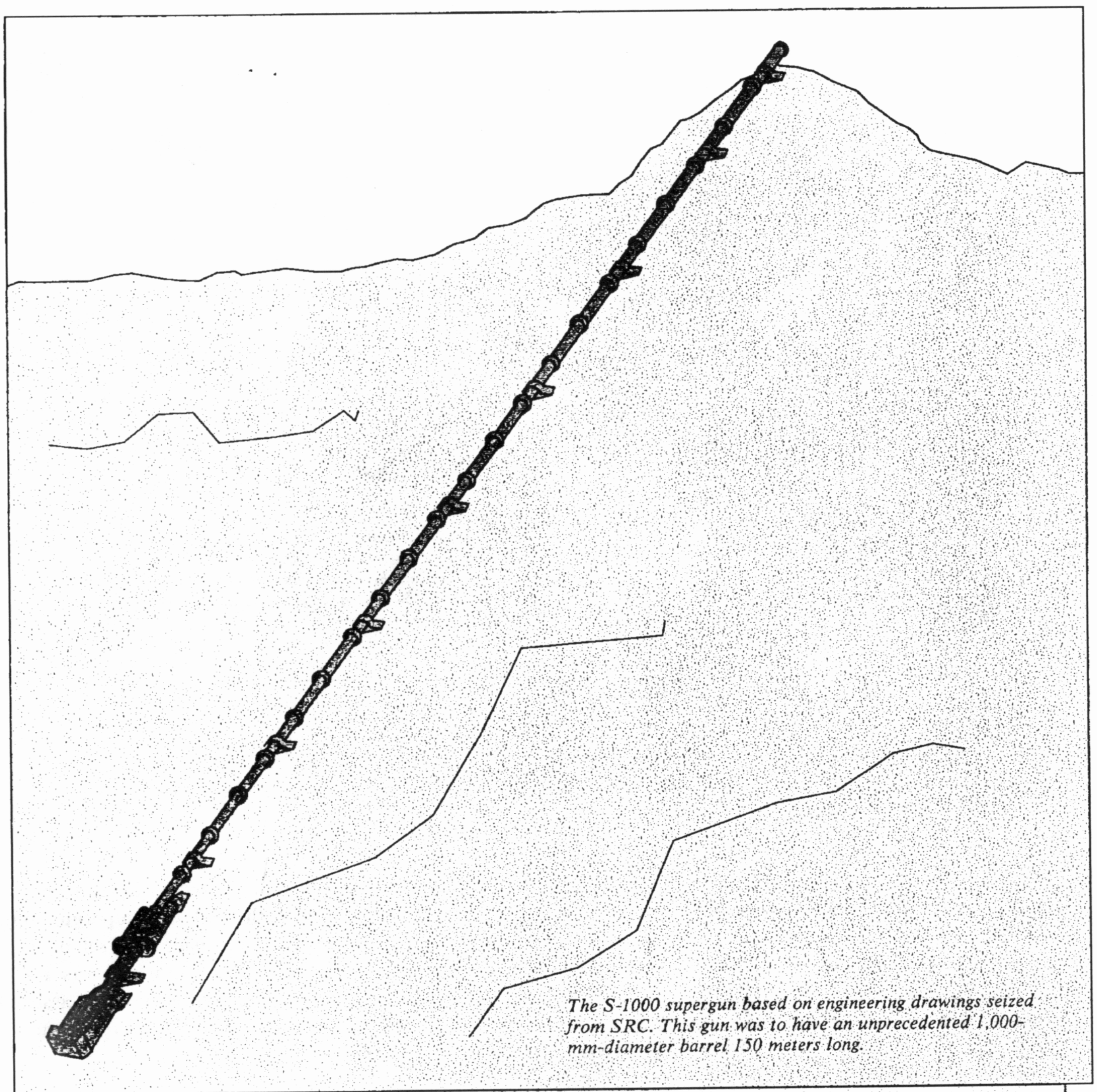
332914 11-91

Figure 8
The S-1000 Supergun



The S-1000 supergun based on engineering drawings seized from SRC. This gun was to have an unprecedented 1,000-mm-diameter barrel 150 meters long.

332915 11-91

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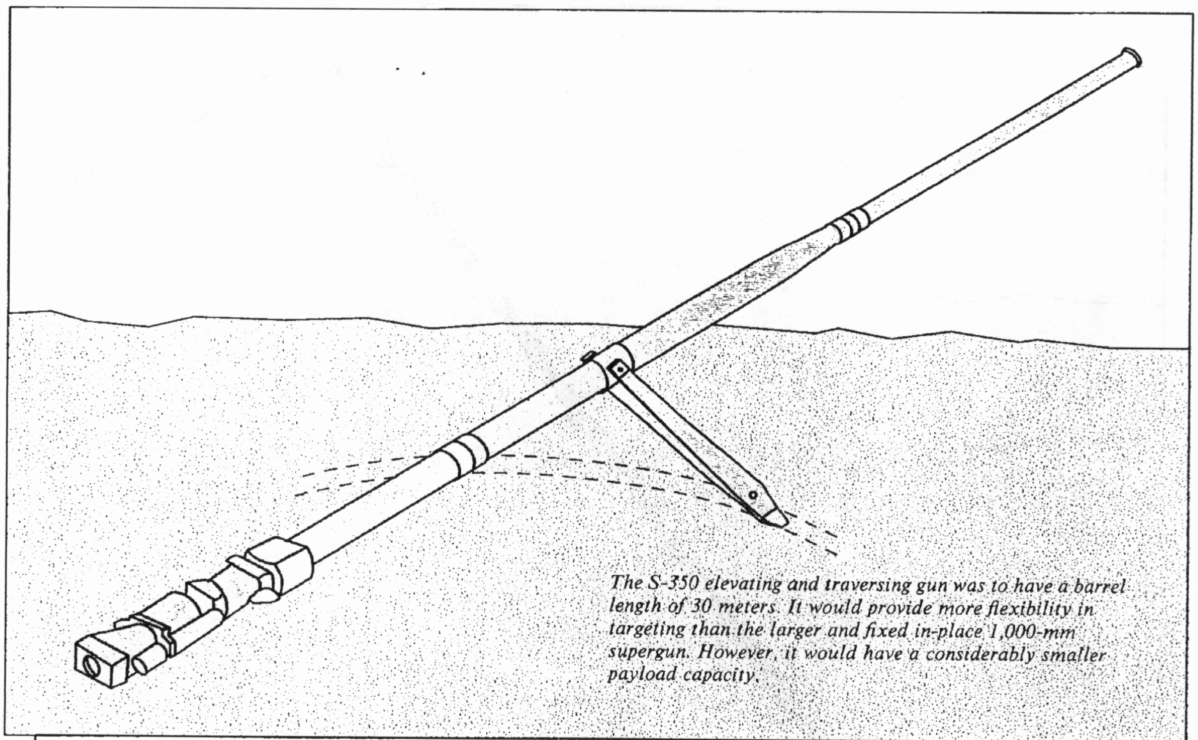
[redacted]

Figure 9
S-350 Elevating and Traversing Gun



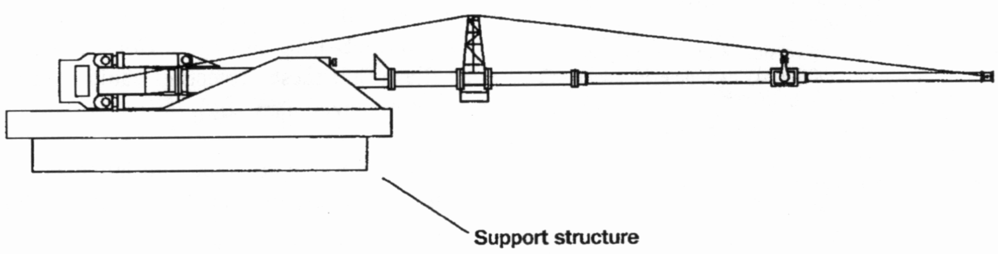
The S-350 elevating and traversing gun was to have a barrel length of 30 meters. It would provide more flexibility in targeting than the larger and fixed in-place 1,000-mm supergun. However, it would have a considerably smaller payload capacity.

[redacted]

~~Secret NOFORN NOCONTRACT~~ 332916 11-91

Unspecified problems during the development of the 1,000-mm supergun were implied by SRC endorsement of another large-caliber gun, as revealed in documentary data. A plan for a 600-mm gun system was in the proposal stage in early 1990 (see figure 10). This gun was to have provided the capability to launch larger payloads than the 350-mm guns, because of its larger size, and was to have provided more targeting flexibility than the fixed 1,000-mm supergun, because it could elevate and traverse. We believe that this 600-mm gun represented a "lower-tech solution" as compared with the larger supergun and, consequently, may have been easier to develop. [redacted] this 600-mm gun was designed to fire subcaliber and (simpler) rocket-assisted projectiles (not GLRs) similar to those fired from conventional artillery guns. ~~(S NF)~~ (b)(1) (b)(3)

Figure 10
The 600-mm Elevating and Traversing Gun



The 600-mm elevating and traversing gun was to have a barrel length of 60 meters. Apparently, SRC was having difficulties with the larger 1,000-mm supergun and was recommending this gun to Iraq.

332917 10-91

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Projectiles
Two projectile types were considered for Project Babylon: subcaliber projectiles and GLRs. These projectile types, like most of Project Babylon, borrowed heavily from the HARP program. A variety of projectiles had been identified and were in various stages of development by early 1990 (see table 1). ~~(S NF)~~

[redacted] cylindrical (b)(1) test slugs were constructed for the proof testing of the (b)(3) S-350 L150 test-gun breech and barrel. These test slugs, though aerodynamically unstable, were intended to duplicate the actual projectile's mass (see figure 11). The test slugs allowed the proper internal gun

Table 1
Project Babylon Projectiles

	Gun (*milli-meters*)	Remarks
Subcaliber projectile		
S31	1,000	Scaled-up version of the S32 test projectile
S32	350	Test projectile; this projectile was successfully fired from the horizontally mounted 350-mm gun
S35	1,000	Scaled-up version of the S36 projectile; about 500-kg payload; no evidence of other than design work
S36	350	First projectile with a "live" load; 22-kg payload
S37	500	78-kg payload; possible scaled-up version of S36; about 450-km range; only in design phase
S43	350	A technology demonstrator; this projectile may have been built
S44	350	A modified version of the S36 projectile; 15-kg payload; 400-km range; only design work done
S46	1,000	Scaled-up version of S44 projectile; 500-kg payload; 700-km range; only in the design phase
S49	600	Rocket-assisted projectile; 100-kg payload; 650-km range
S50	600	600-mm version of S44; 100-kg payload; 500-km range
Gun-launched rocket		
GLR	350	100-kg payload; about 1,000-km range
GLR	1,000	1,000-kg payload; about 1,000-km range
GLR	500	200-kg payload; about 1,000-km range

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pressures to be achieved and provided interior ballistics calibration for the computer codes used in the design of all the guns. In addition, these test slugs allowed SRC designers to determine the proper propellant amount and configuration to achieve optimum performance from the 350-mm gun (see appendix A, "Interior Ballistics"). The final propellant geometry, as determined from the 350-mm gun test firings, would be scaled up for use in the 1,000-mm supergun. ~~(S NF)~~

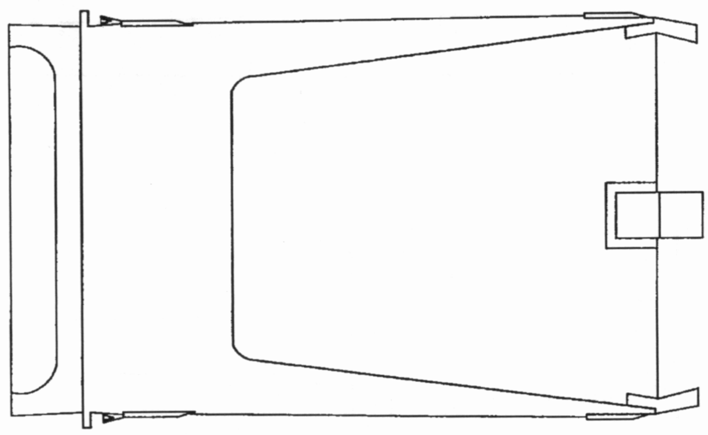
Several test projectiles, designated S32, were constructed and fired from the horizontal S-350 L150 test gun, according to available SRC documents (see figure 12). These projectiles were to be fired downrange for the first time during the inclined S-350 L150 test program. The primary purpose of these projectiles [redacted] was to test the overall configuration of the subcaliber projectiles and provide a basis for extending the design to the S-1000 supergun. Consequently, we do not believe that these projectiles could have been easily weaponized. ~~(S NF NC)~~ (b)(1) (b)(3)

We assess that no completed gun-launched rockets exist for any of the Project Babylon guns. Our analysis [redacted] shows that their design was well advanced by early 1990 (see figure 13). However, much work and testing were required before they could become operational. Even though the Project Babylon GLRs were based on the HARP's designs, SRC gun designers conceded that GLR complexity required extensive out-of-country assistance. ~~(S NF NC)~~ (b)(1) (b)(3)

Guidance and Control

[redacted] show that "no real productive work" had been done on a projectile guidance and control (G&C) system, mainly for the GLRs, through March 1990. Documentary data further reveal that this was an area where SCR designers were least competent. Apparently, SRC personnel with necessary G&C system experience and expertise were not working directly on Project Babylon. Only a general study of G&C schemes, with a superficial analysis of a technique for the Project Babylon projectiles, was presented to Iraq by the SRC. Because so little work was done in this area, Iraq was withholding funding from the SRC until progress was demonstrated. ~~(S NF)~~ (b)(1) (b)(3)

Figure 11
Test Slug Fired From the S-350 Test Gun



The test slug used during pressure proof testing of the S-350 L150 gun. Several of these test slugs were fired from the horizontally mounted gun and were planned for the inclined-gun testing as well.

332918 11-91

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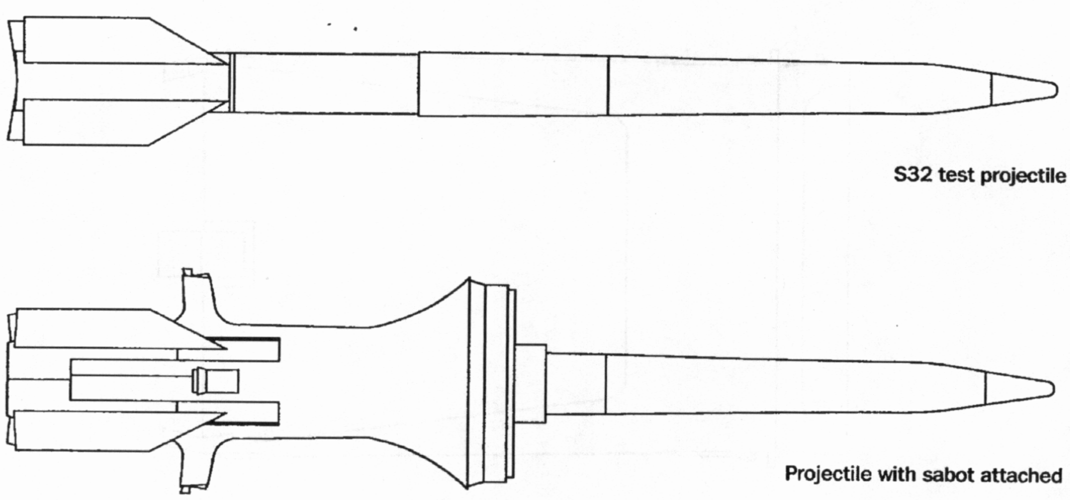
Documentary data reveal that a relatively simple G&C scheme was investigated. A ground-based radar would track the projectile after firing, and a ground-based computer system would combine this tracking data with exit velocity and meteorological data to determine what corrections were required to hit the desired target. Correction commands would be transmitted to the projectile by a ground-based controller, adjusting control surfaces (fins) located on the projectile body, to change its course. This type of G&C system requires that all necessary maneuvering be accomplished while the projectile is in the atmosphere immediately after firing, a period of about 30 seconds, according to SRC calculations. ~~(S NF NC)~~

Figure 12
S32 Subcaliber Projectile for the S-350 Test Gun



The experimental subcaliber projectile designated S32 is the only known projectile to have been fired by the Iraqis during Project Babylon. The lower drawing shows the projectile with its sabot attached.

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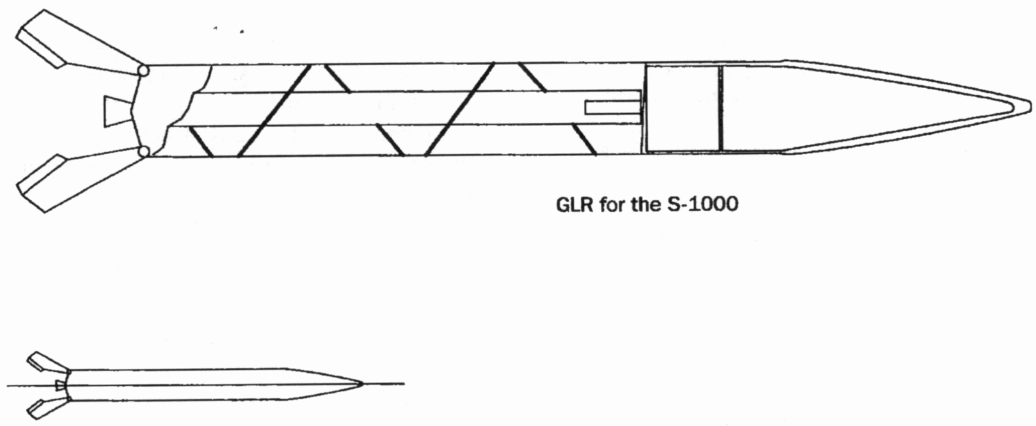
International Participation: Vital to the Project

Participation of companies outside Iraq was essential for Project Babylon. This participation supplemented lacking in-country manufacturing capability and helped to maintain the fast-paced schedule that had been established for the project. The sheer size of the supergun and its components required the support of a variety of companies from all over the world, including the United Kingdom, Switzerland, Spain, Italy, and Belgium (see table 2). These companies manufactured components, including barrel sections, recoil mechanisms, propellant, elevating and traversing

Figure 13
Gun-Launched Rockets



These gun-launched rockets were designed for both the S-350 ET guns and S-1000 supergun. The only difference between the two was to be their size.

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332920 11-91

items, and structural pieces. No one company manufactured all the components necessary to construct a gun, and, apparently, some companies were not even aware that they were building components intended for a gun system. ~~(S NF)~~

Most of the components for all the Project Babylon guns were delivered to Iraq by early 1990, with the exception of some critical components. In April, however, when UK Customs seized the last eight sections that make up the 1,000-mm gun barrel, public disclosure prevented the delivery of any more items. Before then, some 44 other 1,000-mm-barrel tubes had already been delivered to Iraq and had been identified

Table 2
Some of the Companies Involved in Project Babylon

	Country	Description
Forgemasters	UK	Barrel sections for S-1000, cradle for S-350 ET
Walter Somers	UK	350-mm barrel sections, hydraulic components, elevating and traversing components
[redacted]	UK	Barrel flange seals for all guns
[redacted]	Spain	Slide bearings for S-1000, support structure
[redacted]	Spain	Elevating and traversing components
[redacted]	Switzerland	Recoil components for S-1000 and S-350 ET, breech for the S-350 ET
[redacted]	Belgium	Hydraulic components for the S-350 ET
[redacted]	Italy	Barrel and yoke housing for the S-1000
PRB	Belgium	Propellant for all guns

(b)(1)

This table is Secret ~~Noforn Nocontract~~.

at the industrial park at Iskandiaria (see figure 14). In addition, the barrels for the S-350 ET guns had also been delivered to Iskandiaria. The seized components were never delivered, and complete construction of the 1,000-mm supergun and 350-mm elevating and traversing guns could not have taken place without them. ~~(S NF NC WN)~~

The companies primarily involved with the construction of the supergun barrels were in the United Kingdom. Sheffield Forgemasters contracted to build fifty-two 1,000-mm-diameter tubes that would comprise the barrel for the 1,000-mm horizontal test gun and the operational supergun. Walter Somers was commissioned to build the barrels, as well as other components, for the two smaller 350-mm elevating and traversing guns and the 350-mm test gun that was fired. Another UK firm, [redacted] supplied flange seals for the gun barrels of both size guns. ~~(S NF)~~ (b)(1)

Other components for the Project Babylon guns were constructed by various companies from several countries. Two Spanish firms, [redacted] were involved in the construction of elevating and traversing items and structural support pieces. [redacted] of Switzerland built at least one breech for the S-350 ET gun and, in addition to [redacted] of Belgium, built recoil components for guns of both sizes. [redacted] of Italy, supplied a variety of components, including a barrel and yoke housing and possibly a breech for the S-1000 gun. Many of these components were delivered to Iraq by early 1990. ~~(S NF)~~ (b)(1) (b)(1) (b)(1) (b)(1)

The Only Gun To Fire: The S-350 L150

Only one Project Babylon gun was completed and test-fired. The construction of a 350-mm-diameter test gun was completed sometime near the end of 1989, and some firings of the gun in a horizontal position were conducted. This 350-mm gun test program would allow SRC designers to update the 20-year-old HARP program data base with information about guns built with modern materials and about newer construction techniques. We believe that these tests were probably not completed. ~~(S NF)~~

Initially, this test gun was horizontally mounted on railcars and possibly fired as many as 15 test projectiles (see figure 15). Railcars were used because no recoil mechanism had yet been built. The firing of the gun caused the railcars to move backward several meters. By March, this gun was dismantled and reassembled at another test location in the Hamrin Mountains at a 45-degree inclination. ~~(S NF NC OC)~~

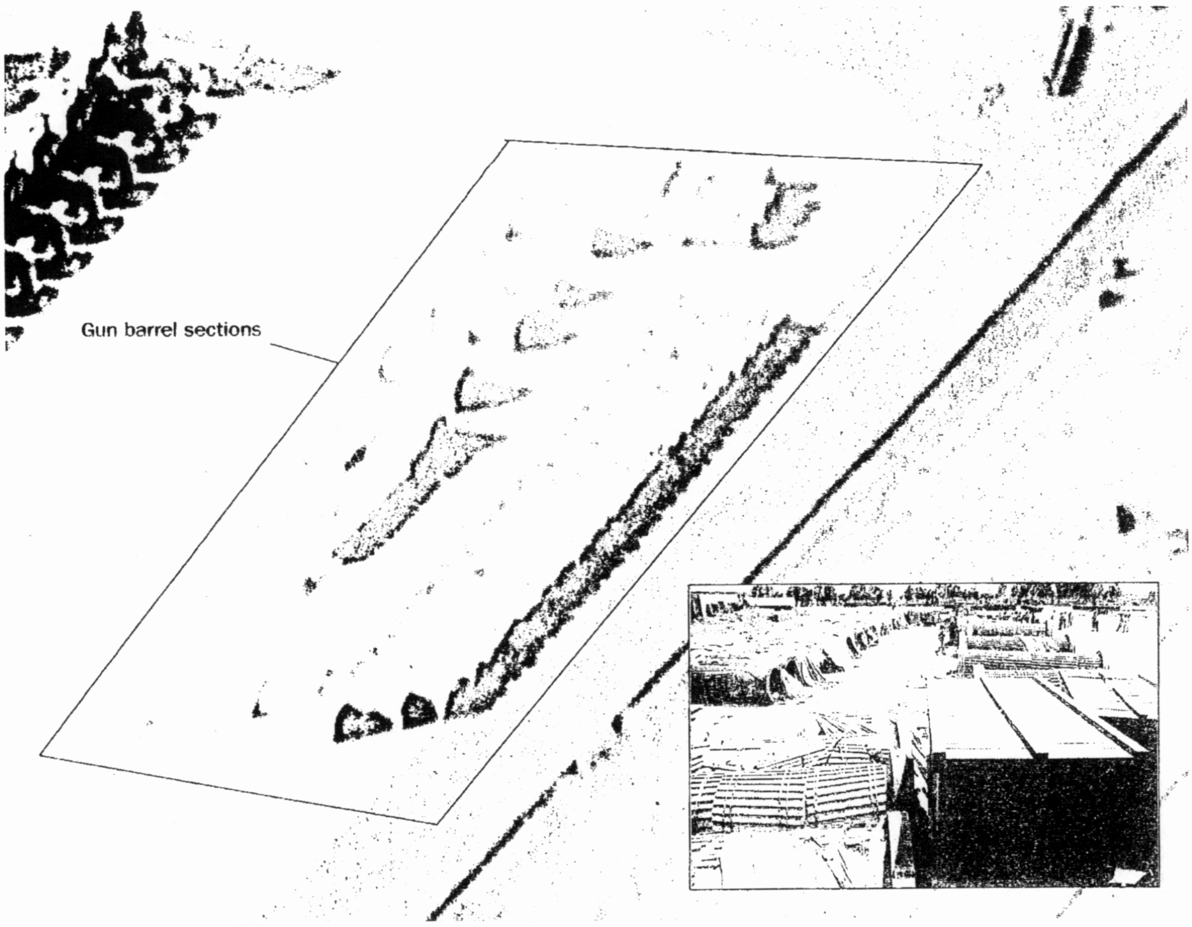
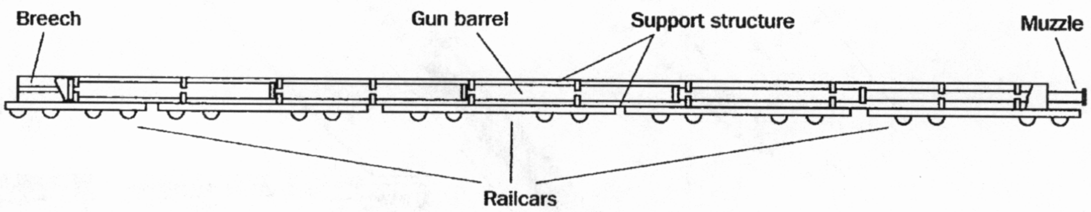


Figure 14. Satellite imagery of Iskandiaria, Iraq, shows what we believe to be the large barrel sections that were to make up the gun barrel for the 1,000-mm supergun. (S ~~NF WN~~)

The final testing of the S-350 L150, with subcaliber projectiles fired downrange for the first time, was to occur at the end of March 1990 (see figure 16). We believe that this test program was probably never completed. These tests were designed to more accurately replicate how the larger supergun would be used. The gun was mounted against the side of a mountain and would fire both subcaliber and rocket projectiles as they became available. Data from these tests were to be used to calibrate the exterior ballistics calculations made for the subcaliber projectiles fired from the 350-mm gun—specifically to determine whether their expected range would be achieved (see appendix B, "Exterior Ballistics"). (S ~~NF NC OC~~)

Figure 15
S-350 L150 Test Gun Mounted on Railcars



The S-350 L150 scaled version of the 1,000-mm supergun, with its 52.5-meter-long barrel, was initially mounted horizontally onto railcars. This facet of the test program was designed to test the overall design and construction concept of the gun.

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A Future for Project Babylon?

We assess that the Iraqi supergun will not be completed, especially since UN inspection teams are rendering the gun barrels inoperable. Further, we believe that Iraq will not continue the development of any of the other 350-mm guns of Project Babylon. Unlike Bull's GC-45 artillery guns, the guns of Project Babylon were not "whole systems" that could be purchased by the Iraqis. ~~(S NF)~~

We believe that Iraqi expectations of the success and progress of Project Babylon were inflated, on the basis

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[redacted]

of promises from the SRC. We are uncertain why the SRC felt the need to conduct such a formidable weapons development program at such an accelerated pace. Even though Project Babylon's foundation was the proven technology of the HARP program, significant development time, representing at least a two- to three-year program, was required according to SRC documents. This development program depended on much work being performed in parallel with out-of-country assistance. ~~(S NF)~~

Notwithstanding the efficiencies of using a gun as a first stage for rocket projectiles and the "reusable" nature of a gun, we believe that the lack of mobility inherent in such a large system would make it vulnerable and place serious restrictions on its use as a weapon in a future conflict. ~~(S NF)~~

Page# 18

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Appendix A

Interior Ballistics

Interior ballistics, for the purpose of this report, is concerned with the calculation of the propulsive forces acting on a projectile during its travel within a gun barrel. For conventional guns, these forces are generated when a propellant charge is ignited. Of primary interest is the internal pressure within the gun, the pressure on the base of the projectile as it travels down the barrel, and the exit velocity of the projectile as it leaves the gun. These data are used to ensure the adequacy of the gun design as well as provide initial conditions (that is, projectile exit velocity) for the computation of the exterior ballistic performance of the projectile. (U)

Suitable techniques for igniting large quantities of propellant were investigated during the join US-Canadian High-Altitude Research Project (HARP). Of particular concern was the proper ignition of a long column of propellant without generating extremely-high-pressure peaks that could ultimately cause failure of the gun tube—a problem that apparently occurred frequently during the HARP program (see figure 17). A unique solution was developed by Gerald Bull during the HARP program. The long column of propellant was ignited at several points, which resulted in lower peak pressures than with conventional base-ignited charges. Consequently, more propellant could be used and, theoretically, higher projectile exit velocities achieved. We assess that a similar ignition system was used on the S-350 L150 test gun. ~~(S NF)~~

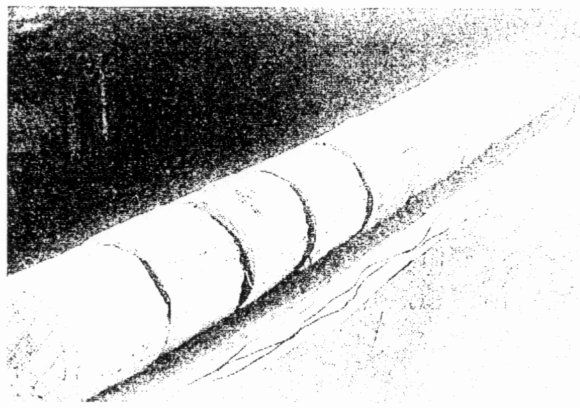

Figure 17. The assembled charge of M8M propellant was used during the HARP program. (U)

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Several candidate propellant compositions were considered in the early stages of charge design for the Babylon guns. It is reported that Bull himself made the final choice of using a propellant known as M8M because of its well-characterized performance during the HARP program. M8M is a seven-perforated, double-base propellant (a propellant that includes nitroglycerine in addition to nitrocellulose), very

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similar to the US M8 propellant used in mortars. However, M8M is modified to permit the use of a dry-pressing process during its manufacture, as opposed to the more common wet process. This manufacturing technique was developed during the HARP program and was found to be necessary to prevent the generation of sporadic high and low pressures within the charge during ignition in large-caliber guns. (~~S NF~~)

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Page# 22

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Appendix B

Exterior Ballistics

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Exterior ballistics deals with the motion of a projectile that has been launched at some angle with some velocity. These calculations are required to evaluate certain performance parameters of a projectile, for example its ultimate range. With the possible exception of the sheer size of the 1,000-millimeter (mm) supergun, the exterior ballistic performance of the Project Babylon projectiles represents one of the most widely publicized aspects of the project. (U)

Initial reports that indicated Iraq was building a gun system capable of launching projectiles to 1,000 kilometers were met with some skepticism. However, review [redacted]

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of the gun-launched rockets (GLRs) reveal that such a capability is possible. [redacted]

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[redacted] Iraq desired to have a 1,000-mm supergun capable of launching a 1,000-kilograms payload to about 1,000 km with a GLR and 700 km with a subcaliber projectile. For the 350-mm guns, a smaller 100-kg payload to about the same 1,000 km with GLRs was intended. ~~(S NF)~~

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percentage. We estimate that the maximum range for the S31, with the lower velocity, to be about 700 km. ~~(S NF)~~

The exterior ballistic performance of the superguns using the GLRs would be remarkable. For the S-350 ET guns, ranges to about 1,000 km were expected carrying a 100-kg payload (see figure 21). Some control was to be applied to the rocket during its glide phase (before rocket-motor ignition), if necessary, to correct for any velocity variations. The rocket motor would ignite at about a 18-km altitude and burn for approximately six seconds, producing a terminal velocity in excess of 3,000 m/s. Shortly afterward, the rocket would leave the atmosphere and continue to its target about 1,000 km from the launchsite. ~~(S NF NC)~~